**Before the**
**FEDERAL COMMUNICATIONS COMMISSION**
**Washington, DC 20554**

| | | |
|---|---|---|
| In the Matter of | ) | |
| | ) | |
| Promoting More Efficient Use of Spectrum | ) | ET Docket No. 10-237 |
| Through Dynamic Spectrum Use Technologies | ) | |
| | ) | |

# REPLY COMMENTS OF V-COMM, L.L.C.


Sean Haynberg
Director of RF Technologies

David Hunt
Senior Staff RF Engineer

David Stern
Vice President

Dominic Villecco
President

V-COMM, L.L.C.
2540 US Highway 130, Suite 101
Cranbury, NJ 08512
(609) 655-1200


March 28, 2011

Table of Contents

**Before the**
**FEDERAL COMMUNICATIONS COMMISSION**
**Washington, DC 20554**

| | | |
|---|---|---|
| In the Matter of | ) | |
| | ) | |
| Promoting More Efficient Use of Spectrum | ) | ET Docket No. 10-237 |
| Through Dynamic Spectrum Use Technologies | ) | |
| | ) | |

# REPLY COMMENTS OF V-COMM, L.L.C.

V-COMM, L.L.C. (V-COMM)[1] submits its reply comments in response to the FCC's Notice of Inquiry (NOI) in the above-captioned proceeding regarding dynamic spectrum use technologies.[2]

## I. INTRODUCTION AND SUMMARY

In response to the NOI, V-COMM analyzed comments submitted in the proceeding and prepared this report. Herein, we address the comments and technical issues associated with third-party opportunistic dynamic spectrum uses in Commercial Mobile Radio Service (CMRS) bands (i.e. Cellular, PCS, AWS, SMR, 700MHz bands, etc.). Previously, V-COMM commented in the NOI proceeding as an attachment to comments submitted by Verizon Wireless on

---

[1] V-COMM, L.L.C. is a wireless telecommunications consulting company with principal members having over 29 years experience in the wireless industry. We have provided our expertise to wireless operators in RF engineering, system design, implementation, performance, optimization, and evaluation of new wireless technologies. We have extensive industry experience in all CMRS technologies. V-COMM's company information and experiences are highlighted in this report's Appendix A, along with biographies of senior members of its engineering team. Verizon Wireless retained V-COMM to evaluate the proposals and comments in the NOI and their potential impact on wireless networks.

[2] *Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies, Notice of Inquiry*, ET Docket No. 10-237 (released November 30, 2010) ("NOI").

February 28, 2011.[3] Therein, we provided reasons that opportunistic underlay spectrum sharing technologies are not compatible with and will cause harmful interference to existing licensed CMRS services.

V-COMM also provided comments in the FCC's Experimental License and Market Trial Notice of Proposed Rulemaking (NPRM) proceeding on March 10, 2011 regarding the use of licensed CMRS spectrum bands for radio experimentation and market trials.[4] The NPRM requested comments on enhancing the development of innovative and new technologies by expanding the scope of its radio experimental licensing program pursuant to Part 5 of its rules. For reasons we provided, the expanded opportunities as proposed in the NPRM for radio experimentation and market trials in licensed CMRS spectrum should not be authorized to third parties, as CMRS bands are intensely utilized, have highly mobile users, and are not suitable for radio experimentation and market trials which would result in harmful interference to existing CMRS services. Further, CMRS bands provide critical Public Safety, E911 and other emergency services that must be fully protected from harmful interference.

V-COMM is an independent engineering firm with extensive experience in CMRS technologies and systems. We have significant experience in CMRS and Public Safety network design and deployments, engineering networks for high performance, optimizing spectrum efficiency, and evaluating new wireless technologies. V-COMM has conducted extensive

[3] Referred as "V-COMM Comments" in this report.

[4] *Promoting Expanded Opportunities for Radio Experimentation and Market Trials under Part 5 of the Commission's Rules and Streamlining Other Related Rules, Notice of Proposed Rulemaking*, ET Docket No. 10-236 (released November 30, 2010) ("NPRM").

interference and compatibility studies within CMRS networks,[5] performed noise and interference studies in CMRS spectrum bands,[6] and participated in numerous FCC proceedings with comprehensive engineering reports.[7]

For reasons provided herein, opportunistic dynamic sharing technologies are unproven technologies that are not compatible with licensed CMRS spectrum bands. The spectrum sensing and geolocation concepts raised in the NOI would not work in licensed CMRS bands and would result in harmful interference to incumbent users if applied to these bands. CMRS spectrum is extremely spectrally efficient, intensively utilized, has high user mobility, and is not suitable for third-party opportunistic sharing. Interference temperature concepts are unworkable, will not enable dynamic spectrum sharing of licensed bands, and would result in increase interference levels within CMRS frequency bands.

Further, we provide additional comments on the use of network-based dynamic spectrum technologies in CMRS networks to enhance spectrum efficiency and utilization. We also address the significant security risks associated with aftermarket modifications of software policy radios, and spectrum that would be suitable for future unlicensed band allocations.

---

[5] V-COMM has conducted extensive compatibility and interference studies within AT&T Wireless' and Verizon Wireless' networks including interference testing of spectrum-sharing technologies and trials within CMRS spectrum.

[6] V-COMM has conducted spectrum noise and interference measurements within Verizon Wireless and AT&T Wireless' CMRS networks. V-COMM submitted the "AMPS Noise Floor Study" within the FCC's AirCell spectrum-sharing proceeding (ET 02-86) on April 10, 2003, and the "PCS Noise Floor Study" within the FCC's Spectrum Policy Task Force Report proceeding (ET 02-135) on Sept. 16, 2003. These spectrum noise studies were also provided as Attachment B and Attachment C to Comments filed by V-COMM in the FCC's Interference Temperature (ET 03-237) comment proceeding on April 5, 2004.

[7] V-COMM has participated in numerous FCC proceedings with comprehensive engineering reports including experimental AirCell, Cellular Airborne, Spectrum Policy Task Force, Ultra-wide band, Interference Temperature, Cognitive Radio, PCS H-Block, AWS-III Block, and Low Power Auxiliary Stations, Wireless Microphones in 698-806 MHz band proceedings.

## II. OPPORTUNISTIC DYNAMIC SPECTRUM SHARING CONCEPTS ARE UNPROVEN TECHNOLOGIES

Many parties provided comments in the NOI proceeding advising the Commission that third-party opportunistic dynamic spectrum sharing concepts are untried and unproven technologies that are not able to share licensed spectrum bands with mobile users without causing harmful interference to existing licensed users. CMRS spectrum bands are intensely utilized, have high user mobility, and are not compatible with third-party underlay spectrum uses. In addition, CMRS bands provide critical Public Safety, E911 and other emergency services that must be fully protected from harmful interference. For these reasons, the Commission should not authorize or rely upon unproven dynamic spectrum access technologies by third parties in licensed commercial mobile bands. Instead, the Commission should consider other more suitable bands (i.e. unlicensed, shared and light-licensed bands) for researching, testing, and developing new and unproven technologies as V-COMM outlined in its comments.[8]

AT&T stresses that "these technologies are inappropriate for use in licensed mobile spectrum, except under the sole control of the licensee. And the proper place for continued development and experimentation of such unproven technologies is not in the commercial mobile spectrum relied upon by hospitals, first responders, utilities, homeland security, and more than 270 million consumers." [9]

APCO cautions against authorization of unproven spectrum technologies can cause dangerous interference to essential Public Safety services and other incumbent services. We agree with APCO's comments that such technologies are in the early stages of development, and long before deployment should be extensively tested in lab and field environments to ensure

[8] V-COMM Comments at 21.

existing licensed systems will not be harmed, particularly systems used to provide safety of life and property.[10] NPSTEC adds that "there is a significant amount of information yet to be learned about how the technology will work in actual practice and in particular, how well it could protect licensed users from interference in a variety of operational environments."[11]

In addition, V-COMM notes that CMRS service is used by Public Safety agencies for priority access and other emergency services including E911 customer services, which is not suitable for experimenting with unproven third-party access technologies.[12] The Commission has observed elsewhere that CMRS spectrum bands provide critical public safety services as well.[13] Ericsson also notes that licensed CMRS spectrum provides critical services and requires high reliability and management of spectrum:

> "Licensed spectrum allows the network operator to provide emergency and real-time services that require reliably managed access to spectrum. Services such as E–911, telephone relay service, and communications relied upon by first responders and other public safety personnel are inherently real-time services requiring protection from interference and assurance of spectrum resources. Reliably managed spectrum access also

---

[9] AT&T Comments at 6.

[10] APCO Comments at 1-2; " APCO urges the Commission to proceed very cautiously, as some of these technologies could create dangerous interference to essential public safety and other incumbent operations. As discussed in the NOI, dynamic spectrum technologies are still in early stages of development, with little or no deployed operations. Long before dynamic spectrum technologies are rolled out for public consumption, there must be extensive testing in both labs and in the field to ensure that existing radio systems will not be harmed, especially those systems that are used to protect the safety of life and property." APCO represents the Association of Public-Safety Communications Officials-International, Inc.

[11] NPSTEC Comments at 4. NPSTEC represents the National Public Safety Telecommunications Council.

[12] V-COMM Comments at 17, "Public Safety uses CMRS spectrum for priority access services, voice communications that supplements their communications services, and critical broadband data communications. In addition, some CMRS spectrum bands are intermixed with Public Safety uses such as 800 MHz LMR bands and could result in adjacent channel interference to Public Safety."

[13] The Commission stated that "the importance of wireless communications for public safety is critical, especially as consumers increasingly rely upon their personal wireless service devices as their primary method of communication." in the *Petition for Declaratory Ruling to Clarify Provisions of Section 332(c)(7)(B) to Ensure Timely Siting Review and to Preempt Under Section 253 State and Local Ordinances that Classify All Wireless Siting Proposals as Requiring a Variance*, Declaratory Ruling, 24 FCC Rcd 13994, 14008 ¶ 36 (2009).

> enables “always-on” connectivity for email and web browsing while supporting services that are sensitive to delays and latency, such as streaming video, high-quality voice telephony, and on-line games, as well as a wide variety of applications such as telemedicine. These services require a managed network using licensed spectrum, not one with opportunistic access to spectrum where priority services would compete equally with secondary services for spectrum access."[14]

Moreover, Ericsson advises the Commission that "regulatory focus is needed on meeting the spectrum demands of the industry in the designated timeframe and should not be bound to concepts, still in consideration, for new regulatory reforms involving unproven models to the detriment of the longer term view." [15]

In contrast to these views, Shared Spectrum believes that their dynamic spectrum access (DSA) technology will fundamentally work and seemingly adapt to almost any environment and any spectrum band.[16] However, Shared Spectrum does not consider the specific uses of critical communications services in various licensed commercial mobile and public safety spectrum bands, nor demonstrate in detail how their DSA sharing technology will prevent interference to very sensitive incumbent licensed users.

## III. OPPORTUNISTIC SENSING AND GEOLOCATION CONCEPTS ARE NOT COMPATIBLE WITH AND WOULD CAUSE HARMFUL INTERFERENCE IN CMRS BANDS

Many parties observed that opportunistic spectrum sensing and geolocation concepts will not work and are not compatible in licensed CMRS bands, and if applied would result in

---

[14] Ericsson Comments at 5-6.

[15] Id. at 21.

[16] Shared Spectrum Comments at pg. 4, "Fundamentally, a DSA-enabled cognitive radio device dynamically adapts to its radiofrequency (“RF”) environment to maintain reliable communications with other DSA enabled devices, and it does so without causing harmful interference to protected “non-cooperative” or legacy systems.", and at pg. 5, "[DSA radios] are capable of safely and reliably operating over a wide span of frequencies by rapidly detecting protected non-cooperative emitters and adjusting their operating frequencies and other transmission parameters in real time."

dangerous interference to incumbent licensed services. For example, Motorola provided significant technical reasons regarding the difficulties in reliable spectrum sensing for opportunistic dynamic sharing technologies in licensed spectrum with mobile users, including the following comments:

> "Prototype WSDs had difficulty reliably sensing the presence of TV band incumbents, whose transmitters are fixed in nature, and typically very high power and high site. Reliable sensing of much lower-power handheld and portable two-way radio transmitters will be orders of magnitude more difficult than detecting high power fixed transmitters. As opposed to TV broadcasts, land mobile radio ("LMR") traffic is highly bursty and unpredictable in nature, which greatly complicates the detection of such transmissions. In addition to the traditional hidden node issues (e.g., shadowing and fading), there are further highly significant incumbent signal losses due to low antenna heights, low antenna gains, body losses, polarization mismatches, and numerous other real-world effects to deal with in the field. Each of the listed effects could result in 10 dB or more of additional signal loss, making sensing of licensed operational incumbents very difficult. Building penetration losses of critical two-way radio communications can easily exceed 20 dB depending on the observation/sensing location. A recent Ofcom study determined that a -126 dBm sensing level was recommended to reliably sense wireless microphones (operating in a 200 kHz bandwidth). The same study examined several other wireless microphone detection scenarios where required detection thresholds were as low as -167 dBm. The mobility of LMR and public safety radios very significantly further complicates the sensing problem, since both ends of a communications link can be mobile, and communications may be highly localized (e.g., in a direct-mode, or talkaround situations). Critical communications may also occur outside of specified service/coverage areas, which forms a challenge to both geo-location database and sensing techniques. In addition, man-made environmental noise can also significantly raise the noise floor, again by 10 dB or more (especially in the lower UHF and VHF bands), making reliable incumbent detection all the more difficult." [17]
>
> "Known challenges include accounting for possible extreme shadowing and fading conditions, keeping observation time short, accounting for non-ideal performance of radio front ends and real world noise conditions, as well as the definition of suitable detection thresholds." [18]
>
> "studies have shown that uncertainty in the noise level gives rise to SNR walls that impede signal detection despite increased observation times. Cyclostationary feature detection techniques degrade significantly in the presence of sample clock offsets. Correlation methods may suffer in the presence of frequency offsets. Each technique has

---

[17] Motorola Comments at 4-5.

[18] Id. at 14.

> its weak points. We believe that it is not possible to arrive at a one-size fits all standard for spectrum sensing, since there are so many variables involved."[19]

Motorola also commented on cooperative sensing techniques contemplated for opportunistic spectrum sensing, and pointed out limitations of such technologies regarding applications in licensed mobile spectrum bands:

> "with cooperative spectrum sensing, correlation in the received signals among the nodes significantly reduces diversity gains. These effects cannot be dismissed, especially in mission-critical environments. As the distance between cooperating radios decreases, the shadowing/fading correlation increases and diversity gains degrade. Similar effects can be observed when detecting groupings of incumbent users (e.g., in a building), as is often the case (e.g., at fire or police incident scenes). Thus, the environment as well as the physical separation between cooperating radios plays a crucial role in determining the effectiveness of the techniques ... real-world testing must take into account a very-wide range of operational possibilities. While there has been a flurry of theoretical and simulation research in the area of cooperative spectrum sensing, there has been limited real-world experience with cooperative spectrum sensing in large scale systems. As a result, the actual benefits and limitations of the technique are yet to be fully established."[20]

> "One issue that needs to be considered with cooperative spectrum sensing is detection delay. The time that it takes to collect and process the sensing information from all of the individual nodes is large, and may result in the cognitive radio system causing harmful interference to bursty primary users while the system processes all the information. The combined sensing results also need to be reliably distributed to all of the cognitive radio devices in the system in a very timely manner, so that they can take the appropriate action. As mentioned, these tasks become even more difficult in the presence of bursty shared mobile radio traffic from incumbents, or even other cognitive systems."[21]

In addition, V-COMM addressed the limitations of cooperative detection concepts and how they cannot overcome the inherent problems of spectrum sensing including hidden node, local clutter and location issues, different receiver and antenna characteristics, introduction of delays in spectrum measurement, detection, and decision making processes, and

[19] Id. at 15.

[20] Id. at 18.

[21] Id. at 19.

incompatibilities with licensed CMRS technologies.[22] As a result, false readings of CMRS spectrum availability will result in opportunistic device transmissions that cause harmful interference to the primary CMRS users. V-COMM also outlined other limitations and problems with spectrum sensing in licensed CMRS bands within its comments, such as the inability to sense a receiver, inability to sense while transmitting, and inability to sense very low signals levels used by CMRS networks.[23]

Advocates of dynamic spectrum access technologies also point out the difficulties and limitations of spectrum sensing techniques for white-space applications in broadcast TV bands, including the Wi-Fi Alliance, IEEE 802.18 and XG Technology in their submitted comments. The Wi-Fi Alliance states "[t]o our knowledge, no sensing technology scales from Personal Area Network to local Area Network to mobile to fixed applications. Further, we are concerned that sensing technology may not prove accurate enough to protect systems with low to medium power transmitters – even sensing (high powered) TV signals proved very difficult. (e.g 2007 FCC OET Outdoor tests). Rather than comment on the states of the art of various sensing technologies, WFA observes that on transmitter detection in shared bands, it is difficult, if not impossible, for a sensing approach to differentiate between a legal device and any other narrowband signals sources such as spurious signals as allowed by Part 15.209(a). To our knowledge, no sensing technology is able to determine the protected legal status of the transmitter of signals which are sensed."[24] IEEE 802.18 states that they " have recognized the

---

[22] V-COMM Comments at 13.

[23] Id. at 4-16. Some CMRS technologies such as CDMA and UMTS operate at very low signal levels to maintain links and optimize spectrum efficiency, which operate below system noise floors with high processing gains inherent in these technologies. These low levels signals cannot be detected by third-party opportunistic sensing devices.

[24] Wi-Fi Alliance Comments at 2-3.

challenge posed by the hidden node issues (e. g., protecting wireless microphones in the TV bands)." [25] And, XG Technology states that the "deployment of spectrum sensing technology in the real world can be very complex, and if the Commission's experience with the TV White Spaces proceeding is any indication, it may be extremely difficult for industry and regulators to reach consensus on common standards that would allow the use of spectrum sensing in licensed spectrum bands."[26]

Further, APCO also urges the Commission to proceed very cautiously as some of these opportunistic dynamic spectrum technologies could create dangerous interference to essential public safety and other incumbent operations.[27] And, V-COMM notes that CMRS bands provide critical Public Safety, E911 and other emergency services, which are not compatible with underlay dynamic spectrum sharing and can result in harmful interference to these critical services, including services operating on adjacent and other bands:

> "Public Safety uses CMRS spectrum for Priority Access Services (PAS), voice communications that supplements their communications services, and critical broadband data communications. In addition, some CMRS spectrum bands are intermixed with Public Safety uses such 800 MHz LMR bands and could result in adjacent channel interference to Public Safety." [28]
>
> "Adjacent channel, adjacent band, and out-of-band emissions can also cause harmful interference to existing licensed services operating in many bands. Some CMRS bands are adjacent to and/or intermixed with Public Safety spectrum bands that are very sensitive to interference from underlay spectrum sharing devices... In conjunction with adjacent band assessments the near-far interference issue should be analyzed to ensure receiver overload and desensitization will not occur to existing services" [29]

---

[25] IEEE 802.18 Comments at 3, ¶ 14.

[26] XG Technology Comments at 4.

[27] APCO Comments at 1-2.

[28] V-COMM Comments at 17.

[29] Id. at 15.

Further, Motorola notes the potential for harmful interference to adjacent bands in its comments due to out-of-band emissions and intermodulation products of cognitive radios:

> "Cognitive radios operating in the public safety and LMR spectrum also have the potential of causing harmful interference to not only co-channel licensed users, but also to adjacent channel users due to the out-of-band emissions (OOBE) and intermodulation products generated as a byproduct of cognitive transmissions that fall outside the channel of operation. Due to the large coverage areas of typical public safety systems, adjacent channel interference by cognitive radios may result in the classic near-far problem where a weak bursty uplink signal from a mobile can not overcome the adjacent channel emissions from an operational cognitive radio." [30]

In addition, Motorola points out a significant incompatibility issue with opportunistic dynamic sharing of licensed bands that has not been addressed by others. In its comments, Motorola raises the issue of underlay dynamic spectrum sharing devices used within range of repeaters. Repeaters are widely deployed in CMRS spectrum outdoors and indoors with distributed antennas systems (DAS).[31] Any opportunistic device transmissions would be received, amplified and retransmitted at higher power levels resulting in interference ranges extending well beyond the local area, with strong levels of interference directed toward victim CMRS base stations that can interfere with all CMRS users on the system.

In this regard, Motorola notes that "cognitive radios operating independently of the primary system must ensure that they do not cause harmful interference not only in the downlink transmissions to mobiles and portables, but also to reception at scattered repeater sites in the uplink, and to any direct-mode (talk-around) portable receivers." [32]

---

[30] Motorola at 5.

[31] Repeaters and distributed antenna systems used indoors are bidirectional amplifiers that amplify CMRS mobile device signals to base stations and amplify CMRS base station signals to CMRS mobile users. Indoor DAS systems operate with multiple indoor antennas serving CMRS customers in buildings with outdoor donor antennas that are orientated toward nearby CMRS base stations.

[32] Id. at 6.

In contrast to the majority, two parties' comments advocate spectrum sensing models to enable third-party opportunistic sharing of commercial licensed spectrum bands. Shared Spectrum provided the following comments:

> “SSC has also been a pioneer in addressing the hidden node problem by developing cooperative sensing (or “group behavior”) solutions. The company’s engineers are currently focusing on difficult noise floor and man-made noise issues to improve the capabilities of our detector algorithms." [33]
>
> "SSC has also implemented and demonstrated the effectiveness of cooperative sensing with its “group behavior” method, which enables DSA-enabled radios to learn where spectrum holes in their vicinity are located and to share this information among themselves ... Specifically, when sensors are paired as indoor and outdoor nodes, the combined information increases the probability of successful detection, ensuring that if one sensor is affected by shadowing or local propagation loss the other sensor is able to provide a more accurate picture. SSC has also implemented and demonstrated the effectiveness of cooperative sensing with its “group behavior” method, which enables DSA-enabled radios to learn where spectrum holes in their vicinity are located and to share this information among themselves." [34]

And, XG Technology commented the following:

> “The ability to detect and avoid other spectrum users will allow commercial and public safety licensees to maximize the efficiency of their networks and it will allow the Commission to maximize the utility of shared use spectrum bands ... In this regard, the Company believes that flexible spectrum sharing rules, conjoined with simple noise floor measurement should be good enough. If a device is aware of its location, if it has a basic internal database of expected primary users and if it can listen for those users, this should be good enough.” [35]

We disagree with Shared Spectrum's and XG Technology's statements that spectrum sensing techniques will allow opportunistic sharing of commercial mobile and public safety spectrum bands without causing harmful interference to these incumbent services, as many others have commented in this proceeding. Moreover, the real-world results of the Commission's white-space tests highlight the practicality and reliability of sensing techniques

---

[33] Shared Spectrum Comments at 9.

[34] Id. at 10-11.

[35] XG Technology at 3-4. We note their term "good enough" is not a scientific conclusion.

that have failed to accurately identify known high-power TV signals and low power wireless microphones in UHF broadcast TV spectrum. These tests depict actual performance under real-world conditions, which is a more reliable measure of a technology's effectiveness as compared to research performed strictly in theory or within controlled laboratory experiments. The Commission cannot rely upon unproven theories an effective policy for spectrum management, particularly in bands providing critical communications such as CMRS and Public Safety bands.

## IV. INTERFERENCE TEMPERATURE CONCEPTS ARE NOT WORKABLE AND WOULD INCREASE INTERFERENCE IN LICENSED BANDS

The Commission should not re-investigate prior interference temperature concepts from an alternate proceeding[36] that was ultimately dismissed by the Commission with commenting parties arguing the approach is not workable and would result in increased interference in licensed bands. Without regard to this assessment, Google urges the Commission to reexamine and adopt the interference temperature model as means of interference management to enable third-party dynamic spectrum sharing of licensed spectrum bands. Google provides the comments: [37]

> "Google supports efficient spectrum sharing through use of technology. Thus, we urge the Commission to reexamine whether to adopt an interference temperature technique as a means of interference management among competing users, as previously recommended by the Commission's Spectrum Policy Task Force. Low-power wideband underlay transmitters are able to monitor interference temperature and adjust their operations accordingly in order to avoid disruption to other users. Consequently, such transmitters enable spectrum sharing even in bands with no unassigned spectrum, and thus are an important means to facilitate flexible spectrum sharing. As Google has stated previously, an interference temperature approach also would improve the Commission's

---

[36] *Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands, Notice of Inquiry and Notice of Proposed Rulemaking*, (Docket No. ET 03-237), released Nov. 29, 2003.

[37] Google Comments at 12.

existing standard of what constitutes potential harmful interference and permit the Commission to provide greater non-interfering access to spectrum in a timely manner."

As V-COMM noted in its Reply Comments in the FCC's Interference Temperature proceeding,[38] the vast majority of comments submitted by the wireless industry, including carriers, equipment vendors, industry associations, standards groups, government entities, and other parties, oppose the FCC’s proposed Interference Temperature (ITEMP) concept. Parties believe that the proposed ITEMP concept is not a workable, practical or feasible solution to improve the use of licensed radio spectrum, nor will it prevent harmful interference to licensed spectrum users. A number of parties, including licensees, equipment vendors, industry groups, and others, cite specific losses in services and reductions in spectrum efficiencies that can occur as a result of unlicensed ITEMP applications in licensed spectrum bands. Based upon the overwhelming response from the industry, the ITEMP concept has many inherent and unresolved problems, and it would not be sound spectrum policy to rely upon such flawed, unproven concepts to manage licensed spectrum bands.

In the I-TEMP comment proceeding, only three parties, Shared Spectrum, Hypres and Agilent offer any support of the ITEMP concept as a means to enable unlicensed devices to share licensed spectrum bands. However, their proposals are not based upon sound reasoning and engineering principles, and in some cases appear to be motivated by self-serving interests, such as allowing their technology free access to valuable licensed spectrum bands. Their proposals contain numerous technical flaws and many unresolved issues that will not protect incumbent licensed networks from harmful interference.

[38] V-COMM submitted comments and reply comments in the FCC’s Interference Temperature proceeding (Docket No. ET 03-237) on April 5, 2004 and May, 5, 2004, respectively.

In particular, many commenters in that proceeding provided sound technical reasons why CMRS bands are particularly ill-suited for unlicensed ITEMP applications, which include: CMRS network and subscriber equipment are very sensitive to incremental increases in the noise floor from external sources; CMRS networks have very high density and mobility of users; CMRS networks utilize many different wireless technologies; CMRS licensees were granted sufficient regulatory flexibility to allow them to optimize spectrum use and efficiency. Even three vocal advocates of increasing unlicensed spectrum use, the IEEE 802.11 group, the Wi-Fi Alliance group, and Proxim, agree that there are difficulties in applying the ITEMP concept to licensed spectrum bands with high density and mobility of users.[39]

Based on these reasons, the FCC should not authorize ITEMP applications in CMRS bands, or other licensed bands with similar characteristics. Authorizing ITEMP devices in CMRS bands will cause serious detrimental harm to services provided by these networks. The impacts to CMRS networks are studied and provided by a number of parties providing comments in the I-TEMP proceeding including AT&T Wireless, Sprint-Telcordia, Motorola, Lucent and V-COMM. All parties show severe detrimental impacts to CMRS networks. When faced with the additional interference from unlicensed devices, CMRS providers must either overbuild their networks to mitigate the effects of the external interference, or provide poorer service to their customers and accept reductions in system coverage and capacity. As given by these impact studies, the harmful impacts to CMRS networks are considerable and the costs to overbuild their networks prohibitively high.

[39] We note that the FCC's Spectrum Policy Task Force (SPTF) report also expressed reservations about the application of this concept to mobile bands, given the difficulties outlined on Page 4 of the SPTF report.

Lastly, most parties reminded the FCC in that proceeding that it should support and strengthen rather than abandon its long-standing neutral position on technology. The Commission should allow market forces to decide and influence technology-based solutions, rather than mandate protocols for an ITEMP application.

In conclusion, the Commission terminated the Interference Temperature proceeding with commenting parties arguing the approach is not workable and would result in increased interference in frequency bands where it is used, in its termination Order dated May 4, 2007.

In the instant proceeding, several parties oppose interference temperature concepts for opportunistic dynamic spectrum access radios as it would result in increasing noise levels in licensed mobile spectrum and result in harmful interference to incumbent services that operates at very low signal and noise levels. For example, AT&T stated that the interference temperature model was supposed to help identify opportunities for additional transmitters to operate in currently licensed bands, particularly unlicensed devices operating on an "underlay" basis. Ultimately, the Commission terminated the proceeding without taking action on the proposals, noting that the "[c]ommenting parties generally argued that the interference temperature approach is not a workable concept and would result in increased interference in the frequency bands where it would be used."[40] Southern Company Services stated that electric utilities expressed grave concerns about the impact that the interference temperature concept could have on system reliability and safety where it would be used.[41]

Ericsson adds that sharing scenarios could similarly increase noise floors within licensee's spectrum and as a result negatively affect coverage, capacity, or quality. Ericsson

[40] AT&T Comments at 4-5.

[41] Southern Company Services Comments at 5.

notes that "sharing requirements on licensed spectrum may further prevent the licensee from introducing new technologies or deploying system upgrades. Lastly, if the licensee's spectrum is shared by a large number of sharing users, it may be impossible, as a practical matter, to reclaim exclusive use if and when harmful interference occurs." [42]

Satellite Industry Association commented that "every dynamic radio within the satellite's coverage area would contribute to an aggregate increase in the noise floor regardless of its proximity to satellite earth stations identified in the real-time database. The overall increase in the noise floor would result in more frequent and longer satellite service outages."[43]

In addition, many parties including V-COMM and the CTIA provided comments that CMRS spectrum has lowered signal and noise levels over time, which are more sensitive to external system interference.[44] In this regard, CTIA states:

> "Advanced power control, for example, allows providers to transmit signals at lower and lower power levels, which has several important consequences. The noise floor decreases over time. As nearby systems use lower signal levels, potentially interfering signals are more attenuated, allowing the use of even more sensitive receivers and lower power levels, which in turn enables greater reuse of spectrum and increased spectrum efficiency. However, use of weaker power signals makes these signals increasingly subject to interference as mobile devices come close to each other, making interference protection even more important." [45]

## V. CMRS SPECTRUM IS SPECTRALLY EFFICIENT AND NOT SUITABLE FOR THIRD-PARTY OPPORTUNISTIC SHARING

The vast majority of parties commenting on CMRS spectrum agree that it operates at very high spectrum efficiency and utilization, and will continue to grow to meet very high

[42] Ericsson Comments at 8.

[43] Satellite Industry Association Comments at i.

[44] V-COMM Comments at 6, 10, 14, 16.

[45] CTIA Comments at 11-12.

projected data demands. Any third-party dynamic sharing of CMRS spectrum will run contrary to CMRS licensees efforts to continue to improve and advance CMRS technologies, and will result in reduction of CMRS spectrum efficiency and innovation. CMRS spectrum also provides critical public safety, E911 and other emergency services for the nation's commercial wireless users and public safety first responders. Therefore, licensed CMRS bands are not suitable for third party dynamic spectrum sharing, which should be considered for other bands (i.e. unlicensed, shared and lightly used spectrum bands).

CTIA commented time and time again they have demonstrated that U.S. mobile wireless providers are the most efficient users of spectrum worldwide, and pack more subscribers into each megahertz of spectrum, enabling more minutes of calling and more megabytes of data usage, than the mobile providers of any other nation.[46]

AT&T stated that licensed CMRS bands are the "most heavily and efficiently used spectrum bands in the U.S., and are relied upon by public safety, utilities, the medical industry, and hundreds of millions of U.S. consumers" and underlay "dynamic spectrum use technologies are technically unsuited for the licensed mobile bands, which are constantly changing and are characterized by an extremely large number of low power transmitters and sensitive receivers with unpredictable usage patterns," [47] and as a technical matter, "the heavily-populated licensed mobile bands present something approaching a worst-case scenario for the deployment of dynamic use techniques." [48] Further it adds that "new air interfaces like LTE often provide increased spectral efficiency, they are also often more sensitive to interference or degradation

---

[46] CTIA Comments at 4-5.

[47] AT&T Comments at i.

[48] Id. at 6.

than legacy systems. Uncontrolled dynamic use devices that do not interfere with current technologies may pose much greater problems as carriers upgrade their networks."[49]

Ericsson notes that CMRS spectrum is very spectrally efficient and licensees are better positioned to drive the adoption of new technologies within their spectrum to meet the increasing demands of consumers:

> "[T]he cellular industry has excelled in the efficient utilization of spectrum and has utilized time, frequency, space and code domains to an extent that would be very difficult for a system of unbridled sharing to match, even if that system was aided by sensing, database, or other techniques. The cellular industry is best positioned to drive the adoption of and to satisfy the mass-market demand for mobile broadband." [50]
>
> "The cellular industry has proven itself time and again to be extremely efficient in its use of allocated spectrum. Year after year, advanced technologies have enabled increasingly efficient use of spectrum in the marketplace. Network operators have repeatedly deployed new technologies to improve their efficiency and carry ever-increasing voice and data traffic loads. For instance, modern cellular systems can operate with 100 percent spectrum reuse by adjusting the loading of cells, and a single network operator's license allows sharing of that spectrum in a controlled way between many users in the same environment. Industry has even developed multi-user transmission techniques that allow sharing of spectrum within the same site. The demands on the acquired spectrum have always challenged the wireless industry's ability to deliver their services with adequate performance and quality, and, accordingly, the industry has always pushed the state of the technological art to yield further efficiencies." [51]

Microsoft also commented that CMRS spectrum is intensively used and it would be inappropriate for mandated underlay smart radios to share their bands, however such technologies should be used by licensees to enhance services or through secondary markets: [52]

> "Notably, because Commercial Mobile Radio Service (CMRS) providers intensively use their spectrum, mandated access by smart radios would not be appropriate in spectrum bands licensed for their exclusive use. However, CMRS carriers should remain free to use dynamic spectrum access technologies and techniques to enhance their own services or in the context of voluntary secondary markets arrangements."

---

[49] Id. at 10.

[50] Ericsson Comments at 3.

[51] Id. at 9.

[52] Microsoft Comments at 2.

Public Interest Spectrum Coalition (PISC) commented as well that intensively used CMRS spectrum bands are least suitable for forced spectrum band sharing, and there are many other bands more suitable for such uses: [53]

> "At the outset, PISC reiterates its contention that frequency bands that are intensively and efficiently in use – such as the bands used for CMRS – are the least suitable candidates for spectrum band sharing, except possibly in geographic areas that are not built out... There are many hundreds of MHz of high-quality spectrum in other bands, far more lightly used and better suited to opportunistic access, than are the PCS and other bands used by the commercial wireless industry."

In addition, AT&T points out to the Commission that opportunistic dynamic spectrum sharing technologies operate on contention-based protocols that are less efficient due to contention among users and increases in retransmissions in high usage areas:[54]

> "[T]he types of contention-based protocols envisioned under dynamic spectrum use are typically inefficient in those high density areas where spectrum is most needed. For example, at high levels of use, contention-based protocols can result in failure due to an exponential increase in the number of retransmits."

Moreover, as many parties have commented in the instant proceeding, the Commission must avoid a "one size fits all" policy approach for managing spectrum in all frequency bands. As many have noted, the sharing concepts developed for broadcast TV bands are not suitable or workable in other bands with high user mobility and very sensitive technologies operating at low signal and noise levels such as in licensed CMRS bands.

For example, TIA urges the Commission to avoid a "one size fits all" policy approach that does not take into account the different services and characteristics in specific frequency bands.[55] Ericsson stated that "“One size fits all” is definitely not the byword for dynamic sharing

---

[53] PISC Comments at 28.

[54] AT&T Comments at 10.

[55] TIA Comments at 2.

mechanisms. A mechanism that might work for a band used by military radar may be a nonstarter for a band used for government mobile communications."[56]

AT&T points out the difficulties in sharing the simple case of broadcast TV bands, and provided reasons that CMRS bands are exponentially more complex and very different than broadcast TV bands: [57]

> "[D]ynamic use technologies are insufficient to adequately protect operations in the broadcast television bands is particularly telling because, in many ways, the broadcast television band is the “simple” case for policy-based sharing devices. The challenges in mobile bands are exponentially more complex, and the stakes are potentially much greater."
>
> "The dynamic nature of network usage also makes mobile wireless systems unfeasible for cataloging through a station database, as contemplated in the TV bands."
>
> "• There are a very discrete number of television broadcast facilities—approximately 9000, including LPTV stations. According to CTIA, there were over 250,000 mobile cell sites in use as of June 2010 and more than 292 million mobile subscriber connections.
>
> • Television broadcast facilities are only rarely modified. In contrast, mobile carriers add base stations and modify their network topographies nearly constantly.
>
> • TV broadcast facilities generally operate at very high power levels and the TV receivers require a good signal-to-noise ratio (or signal to interference-plus-noise ratio) to operate correctly. In contrast, the W-CDMA and LTE radio technologies can be successfully received when the signals are below the noise floor and so spectrum sensing devices may not detect the presence of these signals when close to a licensed receiver.
>
> • Television broadcast stations are predominantly one-way transmitters meaning that the occupied channels are carrying transmissions at all time. Mobile systems, however, often use different spectrum bands for the uplink and downlink segments, meaning that cognitive radios may erroneously detect no activity in a portion of the band, notwithstanding the fact that a call is in session. And the parameters of mobile channel use are so quick – it would be extremely difficult for a sensing device to monitor and switch in rapid enough fashion to ensure that a mobile channel was not in use at a given time.
>
> • Over 90 percent of television receivers actually obtain their signals from nonbroadcast means, whether cable television or satellite; the number of television users who rely on over the air broadcasts and live in marginal signal strength areas is very small. On the other hand, there over 292 million mobile users that all must obtain access from the wireless network.

[56] Ericsson Comments at 17.

[57] AT&T Comments at 12-13.

> • While the distribution of Emergency Alerts over broadcast television is undeniably important, in most cases the interruptions caused by debilitating interference to television systems can be overcome through other technologies and the emergency information can still be communicated. The same is not true of mobile services which are often an individual's only means of communication. Given the high percentage of 911 calls originating from mobile phones, interference to licensed mobile operations could affect the safety of life and property. Moreover, a great number of public safety agencies rely upon licensed mobile service devices to communicate."

Therefore, it is apparent from various parties' comments that sharing concepts under developed for unlicensed uses in broadcast TV spectrum cannot be applied to licensed CMRS spectrum bands. However, a few parties suggested that the broadcast TV spectrum sharing model be applied to other bands. For example, Google provided the comments:

> "As we discuss, the Commission's TV bands white spaces proceeding should serve as a reliable baseline against which to test and build upon dynamic spectrum access rules and policies that could be applied to other bands. Fundamentally, all parties must have an understanding of what, where, and how spectrum is being used. This requires a spectrum inventory that is transparent to users and innovators. This approach was adopted by the Commission in the TV white spaces and should be applied in a more comprehensive fashion to promote dynamic spectrum technologies across all spectrum bands." [58]

We disagree with Google's comments that TV white-space sharing approaches can be applied to other licensed bands such as CMRS with high user mobility and very low operating signal levels. Further, Google does not explain how such concepts can be applied to other bands and how incumbent services would be protected from interference. TV band white spaces represent a specific case with high power transmitters operating at fixed locations, which is very different than operations in other bands in particular CMRS bands.

XG technology suggests that geolocation concepts from TV white-space sharing of broadcast TV bands may be applied to other spectrum bands, "under such a system, devices would rely on a real-time database to obtain up-to-the-minute information on spectrum

[58] Google Comments at 2-3.

availability for any given location."[59] Shared Spectrum believes that unlicensed spectrum uses will translate into new ways to regulate other spectrum bands assuming a "one size fits all" mentality, "technological success on an internal and cooperative basis and in unlicensed bands will pave the road for what should ultimately be recognized as a paradigm shift in how spectrum is regulated and used." [60]

As stated above, we disagree with the assertion that TV white-space sharing techniques can be applied to other licensed spectrum bands particularly CMRS bands. As provided in V-COMM Comments, such third party sharing techniques are not compatible and will result in harmful interference to incumbent CMRS users. Other parties' comments agree and note that the Commission cannot take a "one size fits all" approach to spectrum policy.

## VI. NETWORK-BASED DYNAMIC SPECTRUM TECHNOLOGIES ARE USED IN CMRS NETWORKS

Network-based dynamic spectrum and cognitive radio technologies are heavily used in today's CMRS networks and enable licensees to optimize the use of their spectrum band and provide services hundreds of millions of CMRS customers. CMRS networks operate at the highest level of spectrum efficiency and utilization compared to other bands in the radio spectrum. This is achieved by the advanced technologies used in CMRS, which are more advanced and more efficient than the dynamic spectrum use technologies proposed in the NOI.

V-COMM has provided many examples of the advanced and dynamic spectrum use technologies used in CMRS networks today in this proceeding,[61] which include CMRS advanced

[59] XG Technology Comments at 12.

[60] Shared Spectrum Comments at 18.

[61] V-COMM Comments at 18-19.

scheduler algorithms, network of interconnected base stations communicating and optimizing spectrum use for all users, advanced adaptive modulation techniques that adjusts and optimizes spectrum utilization accordingly to the RF environment, dynamic power control adjusting and optimizing power levels a thousand times a second, advanced spectrum management techniques, MIMO antenna systems using multiple polarities, and diversity transmit and receive algorithms such as spatial-multiplexing, and other dynamic spectrum use technologies to optimize spectrum utilization and efficiency.

Other parties also commented that network-based dynamic spectrum and cognitive radio technologies are used in today's CMRS networks including AT&T, CTIA and Ericsson. AT&T highlights network-based cognitive radio uses in CMRS spectrum with the ability to optimize the spectrum utilization and maximum the efficiency to serve all customers:[62]

> "AT&T already employs cognitive radio techniques in its network that allow wireless base stations to sense and schedule traffic and thus achieve better efficiency. AT&T continues to work with standards bodies, such as the Third Generation Partnership Program ("3GPP"), to improve and extend the uses for these techniques. However, it bears stressing that these applications are only appropriate for licensed spectrum bands when under the fully coordinated control of the network. While cognitive radio technology holds potential for allowing a network operator to maximize the value of its own spectrum resource, third parties have no incentive to maximize the efficiency and value of the network as a whole nor do they have the ability to understand the ramifications of their spectrum usage on overall network performance."

CTIA provides that dynamic spectrum technologies are used in CMRS networks today and are used to serve millions and millions of subscribers:[63]

> "It is important for the Commission to recognize that commercial mobile providers use dynamic sharing technologies within their networks to improve spectrum efficiency and provide more and better services to millions and millions of subscribers. Network-based dynamic sharing technology is a reality today and its benefits are real – separate and apart from questions of third party or autonomous access to spectrum"; and

[62] AT&T Comments at 9.

[63] CTIA Comments at 4-5, 8.

"Commercial mobile providers employ a range of sophisticated dynamic sharing techniques, including a significant number of possible modulation and coding methods that change dynamically to enable the highest possible data rates. The combination of modulation and coding can be different for each subscriber depending on the given circumstances and vary dynamically through instantaneous adjustments."

Ericsson adds that the cellular industry has developed technologies that push the capability of deployed systems across four generations of system infrastructure including the following advanced CMRS spectrum technologies:[64]

"• Adaptive coding and modulation and the introduction of incremental redundancy allow the communication to closely follow the variations in the radio environment.

• Beamforming and MIMO have been incorporated into systems as standard features that have improved capacity and peak data rates significantly across the last two generations of cellular systems.

• Increased processing power in receivers with more efficient power usage has led to the development of signal processing techniques such as Multi-User Detection ("MUD"), and Successive Interference Calculation ("SIC") or a companion version multi-stage SIC, which have greatly improved the ability of a mobile radio to extract a desired signal from a veritable soup of interference.

• Greater coordination between the cells in the operator's network can increase system performance. For example, Inter-Cell Interference Coordination ("ICIC") can improve the data rates of the lowest quartile of users in a cell, potentially improving overall user satisfaction.

• Advanced transmission schemes such as Coordinated Multi-Point ("CoMP") will allow transmission from multiple antenna sites, allowing energy to be directed towards the user while simultaneously reducing the interference to other users. In addition, multi-site receive antennas may also be used in this manner to achieve improved peak data rates. CoMP may also be combined with beamforming."

In addition, it was commented that these advanced CMRS network features and technologies cannot optimize the use of spectrum if underlay devices are operating within CMRS spectrum, which would degrade CMRS spectrum efficiency. CMRS systems manage and optimize the use of CMRS spectrum for all users with network techniques that allocate spectrum according to the needs of all users.  This is in contrast to uncontrolled underlay sharing systems

[64] Ericsson Comments at 10-11.

that optimize spectrum uses for their individual needs and may not relinquish it for other users (i.e. “spectrum hogs”).[65]

## VII. AFTERMARKET MODIFICATION OF SOFTWARE POLICY RADIOS REPRESENTS SIGNIFICANT SECURITY RISKS

There are significant security risks associated with software policy radios that the Commission should recognize regarding the ability to drastically alter the behavior of devices, which can result in harmful interference to many users on many spectrum bands. After they are placed in operation in the marketplace, the behavior of software modifiable radios are at the mercy of hackers, 'jail breakers', and other after-market software-modders that can modify radio operating parameters, software policies, and radio properties at will without any control of the manufacturer of the devices or the FCC. Further, software policy radios can be compromised by malware received over-the-air or by loading software or entirely new operating systems directly onto the radio devices. In addition, this would lead to difficult enforcement issues with compromised software radio devices that would be next to impossible to retrieve from the market let alone detect the extent of harmful interference occurring to primary licensed users due to the nomadic and decentralized nature of these devices.

AT&T noted the concern for end-user modification of policy radios in ways that could cause significant harmful interference to critical communications services:[66]

> "AT&T notes that the potential for harmful interference is of particular concern with respect to “policy radios,” which are dynamic devices operating pursuant to a set of rules intended to govern a range of devices. The threat here is that policies are not native to the device, and devices are likely to be inherently capable of operating pursuant to different sets of policies under different circumstances. As the policy rules may not be “hard-wired” into the devices, the potential exists for end users to modify the operations

[65] V-COMM Comments at 19.

[66] AT&T Comments at 20-21.

> of the device, in contravention of accepted policies, in such a way as to pose a threat to licensed commercial users as well as government and public safety communications.
>
> Although AT&T recognizes that locks or controls may be deployed to prevent such tampering, it is instructive that virtually every attempt to lock down consumer devices has eventually been circumvented. For example, copyright protection encryption built into consumer DVD and Blu Ray Discs have been completely nullified and pirates are now able to access the source code of these encrypted media at will. Perhaps more relevant are the "hacks" that have been used to "jailbreak" mobile phones, modify video game consoles, and unlock unauthorized functionality in e-readers.
>
> In many cases, widely available scripts allow unauthorized capabilities of consumer devices to be exploited by users without any degree of advanced understanding of the technology. This situation presents an even greater risk that not only will the policies be circumvented, but that these radios will be misused by technically unsophisticated consumers. The likelihood of circumvention of these devices combined with the difficulty in identifying them as causes of harmful interference makes for a serious threat that policy radios could cause significant harmful interference to commercial users and critical services. As such, AT&T cautions that any experimentation with policy devices must proceed very cautiously."

AT&T also recognizes the difficulty in detecting devices that dynamically change their operating parameters and cause transient interference, and notes that "even upon identifying the source of interference as being a dynamic spectrum use device, because of the nomadic and decentralized nature of these devices, there may be no straightforward way to locate the device and prevent the interference from reoccurring." [67]

Other parties noted similar security risks concerning end-user modifications of policy radios including the parties that are proponents of opportunistic dynamic spectrum sharing technologies such as Wi-Fi Alliance and Wireless Innovation Forum. The Wi-Fi Alliance noted that "entities that are present on the Internet are susceptible to various kinds of Denial of Service ("DoS"), cyber attacks and related information assurance issues. The level of effort required to stage such attacks are low and the risk of system failure is very high. Another issue of manual entry database is that of trust."[68] The Wireless Innovation Forum notes that "some of the

---

[67] Id.

[68] Wi-Fi Alliance Comments at 4.

potential concerns include possible data falsification, quiet period jamming, false coexistence information, and cognitive radio viruses",[69] and "security breaches can lead to catastrophic failures, particularly when policy or geo-location information is disrupted."[70] The Wireless Innovation Forum cited the following security issues in its comments:[71]

> "• Spectrum sensing data falsification in the context of cooperative sensing of primary users;
>
> • Quiet period jamming which reduces the ability of a secondary system to sense a primary system;
>
> • Replay sensing attacks;
>
> • False coexistence information such as requesting excessive bandwidth or manipulating the beacon in IEEE 802.22;
>
> • Honey pot attacks that lead users to vulnerable states by selectively jamming good states;
>
> • Chaff point attacks that mistrain signal classifiers;
>
> • Primary user emulation attacks where characteristics of a primary user are spoofed to impact the behavior of secondary CRs;
>
> • Belief manipulation attacks wherein the learning phases of CRs are subverted to train the systems to operate in undesirable states, e.g., by jamming the "correct" choices and leaving the "wrong" choices unmolested;
>
> • A "cognitive radio virus" wherein cooperative learning or shared software allows a single compromised radio to propagate problems across a network;
>
> • Injecting policies that prevent or deny CR communications on primary channels;
>
> • Blocking location information or policy information;
>
> • Jamming at spectrum handoff; and
>
> • Inducing receiver errors."

The Satellite Industry Association highlighted the impossibility of enforcement of such dynamic spectrum sharing devices in licensed spectrum:[72]

> "Enforcing non-interference requirements would be impossible, particularly if the Commission authorized dynamic spectrum access radios to be deployed ubiquitously and used for mobile or unlicensed operations. The satellite industry and the Commission

---

[69] Wireless Innovation Forum Comments in Executive Summary.

[70] Id. at 15.

[71] Id. at 14-15.

[72] Satellite Industry Association Comments at ii.

> learned this lesson ten years ago with unlicensed radar detectors that caused harmful interference to Very Small Aperture Terminals ("VSATs"). In that case, the Commission recognized that satellite operators could not identify the individual sources of interference due to the mobile nature and intermittent transmissions of radar detectors."

Also, the CTIA noted the impracticality of enforcement efforts after unlicensed devices enter the marketplace:[73]

> "Unlike licensed transmitters, unlicensed devices enter the marketplace in an uncontrolled manner and enforcement efforts are, for all practical purposes, extremely limited. As the Commission's 2003 Cognitive Radio Notice of Proposed Rulemaking recognized, proposals that rely on cognitive radio technology to limit the risk of interference create "the possibility of new types of abuse.""

In contrast to these parties concern of the security issues associated with the ability to modify a policy radio's operating parameters aftermarket, Shared Spectrum suggested that opportunistic policy radios should be applied to most if not all spectrum bands with the requirement that they are reconfigurable after being sold to end users.[74] V-COMM and many others do not agree with these suggestions by Shared Spectrum, and the Commission should recognize the relative ease and significant security issues associated with software policy radios ability to drastically alter the behavior of devices, which can result in harmful interference to many users on many spectrum bands.

---

[73] CTIA Comments at 14.

[74] Shared Spectrum Comments at 20; "SSC is pleased with the Commission's recognition of the capabilities of policy-based radios and we therefore suggest that the Commission's broader DSA regulatory "Policies" be centered around a policy-based approach that would apply across most, if not all, spectrum bands."; "SSC suggests that the Commission would require eligible RF devices to be reconfigurable to prevent spectrum squatters and ensure that they can be updated after being sold to end users."

## VIII. FUTURE UNLICENSED BANDS SHOULD OCCUPY SPECTRUM ABOVE 5 GHZ AS WIDE-AREA UNLICENSED DEPLOYMENTS ARE NOT SUCCESSFUL

There were many unsuccessful attempts at providing city-wide wide-area deployments in unlicensed spectrum that have proven to be non-viable and non-sustainable mobile service deployments. Ericsson notes the following in its comments citing the unsuccessful deployments in San Francisco, Philadelphia, and Portland:[75]

> "Wi-Fi has not been very successfully deployed in wide-scale (e.g., city-wide) commercial networks. This is the case, at least in part, because such deployments need complex network management—i.e., authentication, radio resource management, call handling, and roaming and must handle nomadic or mobile users. In addition, Wi-Fi networks available on city streets have poor penetration into homes and apartments. Moreover, the spectrum efficiency of Wi-Fi is poor in comparison to modern 3G networks, and it is difficult for a Wi-Fi operator to assure the same quality of service as a cellular operator. As a result, the ad hoc nature of Wi-Fi deployment can leave it susceptible to the effects of interference, especially when it is deployed in close proximity to other Wi-Fi systems or in an area with a dense population of Wi-Fi users. Under such circumstances, Wi-Fi can be subject to significant degradation, to the point of unusability"

Another unsuccessful deployment was Metricom's Ricochet service using unlicensed 900 MHz and 2.4 GHz spectrum. Metricom deployed a wide-area wireless network in unlicensed spectrum system using its patented frequency-hopping spread-spectrum packet-switching data technology. At its height, in early 2001, Ricochet service was available in Atlanta, Baltimore, Dallas, Denver, Detroit, Houston, Los Angeles, Miami, Minneapolis, New York City and surrounding New Jersey, Philadelphia, Minneapolis-St. Paul, Phoenix, San Diego, San Francisco, Seattle, and Washington, D.C. About 51,000 subscribers paid for the service. In July 2001, however, Ricochet's owner, Metricom, filed for Chapter 11 bankruptcy and shut down its service.

In addition, there have been many other unsuccessful municipal and commercial (i.e. Earthlink) wide-area unlicensed deployments that were planned and attempted, which were hampered by interference and service reliability issues, the uncertainty and sustainability of unlicensed spectrum, and limited service ranges due to prevalent interference in unlicensed bands.

Further, others have characterized unlicensed bands (i.e. 900MHz & 2.4GHz) as the "tragedy of the commons",[76] which results in limited spectrum usability and ranges due to prevalence interference from other users. With the extended interference ranges that can occur in the lower frequency bands unlicensed uses are not suitable for these frequency bands, and should be reserved for operation at higher frequency bands to better control and avoid interference among users.

In contrast to these unsuccessful wide-area service deployments, unlicensed spectrum Wi-Fi uses have been very successful for smaller hot-spot service areas (i.e. in homes, small office areas, fast-food restaurants, coffee houses, etc.). For these smaller hot-spot areas, the limited coverage ranges allow the system to mitigate and overcome the interference issues prevalent in unlicensed bands.

For these applications we note that higher frequency operation for unlicensed services is desirable as interference is less of a concern due to the shorter interference ranges and more availability of spectrum. Higher frequency operation would promote more sharing with better reuse of unlicensed spectrum, and more available bandwidths at higher frequencies that are

---

[75] Ericsson Comments at 15. Also provided is an example of Steve Jobs requesting that Wi-Fi devices be turned off at an event due to overload and causing interference.

appropriate for local area coverage networks. Thus, as a general guideline any future allocations of unlicensed spectrum should be above 5 GHz, which is more appropriate for unlicensed applications.

Professor Grunwald also notes that longer propagation ranges are not suitable and results in more interference in unlicensed bands, while 5 GHz spectrum would result in less interference to neighboring users:[77]

> "[L]onger range is not always better - in environments with many different networks, such as cities, long-range networks are more likely to interfere with one another. Although the 5 GHz signal required more power to cover the same area, it attenuates quickly enough that the interference with neighbors is less likely."

## IX. CONCLUSION

For reasons provided above, the Commission should not authorize opportunistic dynamic spectrum sharing within licensed CMRS bands, which are not compatible with advanced CMRS technologies and would result in harmful interference to existing and future CMRS services. CMRS spectrum is intensely utilized, extremely spectrally efficient, and has high user mobility that are not suitable for third party underlay devices to co-exist within, and would result in a decrease in spectrum efficiency if authorized.

CMRS networks use more advanced forms of dynamic spectrum use technologies in their networks today to manage and optimize the utilization of spectrum. CMRS licensees have incentives to deploy dynamic spectrum uses in their spectrum pursuant to flexibility and secondary market authorizations.

---

[76] The "tragedy of the commons" illustrates the philosophy that destructive use of public reservations ("the commons") by private interests can result when the best strategy for individuals conflicts with the "common good".

[77] Professor Dirk Grunwald Comments at 23.

Licensed CMRS bands are not suitable for opportunistic spectrum sharing, which have the highest mobility, utilization, and spectrum efficiency as other bands, and provides critical Public Safety, E911 and other emergency services. The Commission should consider other bands more suitable for the research and development of new and unproven technologies that will not interfere with existing licensed services.

Respectfully Submitted,

Sean Haynberg


Sean Haynberg
Director of RF Technologies

David Hunt, Senior RF Engineer
David Stern, Vice President
Dominic Villecco, President

V-COMM, L.L.C.
2540 US Highway 130, Suite 101
Cranbury, NJ 08512
(609) 655-1200


Filed: March 28, 2011

## APPENDIX A – COMPANY INFORMATION & BIOGRAPHIES

V-COMM is a leading provider of quality engineering and engineering consulting services to the worldwide wireless telecommunications industry with offices in Cranbury, NJ and Blue Bell, PA. V-COMM's engineering staff is experienced in Cellular, Personal Communications Services, 700 MHz Spectrum, Wireless Broadband Data, Enhanced Specialized Mobile Radio, Paging, Public Safety, 2-Way radio, Microwave, and Broadcast Mobile TV. We have provided our expertise to wireless operators in engineering, system design, implementation, performance, optimization, and evaluation of new wireless technologies. We have extensive experience in studying interference in various spectrum bands including Cellular, SMR, PCS, AWS, Air-to-ground, Public Safety, and 700 MHz spectrum. We have engineering experience in all commercial wireless technologies, including LTE, HSPA, UMTS, EVDO, CDMA, GSM, EDGE, WiMAX, MediaFLO, DVB-H, and Public Safety wireless technologies including analog and digital Project 25, EDACS, Opensky, and other trunking and conventional radio networks. Further, V-COMM was selected by the FCC & Department of Justice to provide expert analysis and testimony in the Nextwave and Pocket Communications Bankruptcy cases. For additional information, visit V-COMM's web site at www.vcomm-eng.com.

## BIOGRAPHIES OF SENIOR MEMBERS OF ENGINEERING STAFF

**Dominic C. Villecco**
**President and Founder, V-COMM, L.L.C.**

Dominic Villecco, President and founder of V-COMM, is a pioneer in wireless telecommunications engineering, with over 29 years of executive-level experience and various engineering management positions previously held. Under his leadership, V-COMM has grown from a start-up venture in 1995 to a highly respected full-service wireless telecommunications engineering firm.

In managing V-COMM's growth, Mr. Villecco has overseen expansion of the company's portfolio of consulting services, which today include a full range of RF and Network support, network design tools, measurement hardware, and database services as well as time-critical engineering-related services such as business planning, zoning hearing expert witness testimony, regulatory advisory assistance, and project management.

Before forming V-COMM, Mr. Villecco spent 10 years with Comcast Corporation, where he held management positions of increasing responsibility, his last being Vice President of Wireless Engineering for Comcast International Holdings, Inc. Focusing on the international marketplace, Mr. Villecco helped develop various technical and business requirements for directing Comcast's worldwide wireless venture utilizing current and emerging technologies.

Previously he was Vice President of Engineering and Operations for Comcast Cellular Communications, Inc. His responsibilities included overall system design, construction and operation, capital and operating budget preparation and execution, interconnection negotiations, vendor contract negotiations, major account interface, new product implementation, and cellular market acquisition. Following Comcast's acquisition, Mr. Villecco successfully merged the two departments and managed the combined department of 140 engineers and support personnel.

Mr. Villecco served as Director of Engineering for American Cellular Network Corporation (AMCELL), where he managed all system implementation and engineering design issues. He was responsible for activating the first cellular system in the world utilizing proprietary automatic call delivery software between independent carriers in Wilmington, Delaware. He also had responsibility for filing all FCC and FAA applications for AMCELL.

Prior to joining AMCELL, Mr. Villecco worked as a staff engineer at Sherman and Beverage (S&B), a broadcast consulting firm. He designed FM radio station broadcasting systems and studio-transmitter link systems, performed AM field studies and interference analysis, and TV interference analysis, and helped build a sophisticated six-tower arrangement for a AM antenna phasing system. He also designed software for FM allocations pursuant to FCC Rules Part 73.

Mr. Villecco started his career in telecommunications engineering as a wireless engineering consultant at Jubon Engineering, where he was responsible for the design of cellular systems, both domestic and international, radio paging systems, microwave radio systems, two-way radio systems, microwave multipoint distribution systems, and simulcast radio link systems, including the drafting of all FCC and FAA applications for these systems.

Mr. Villecco has testified as an expert witness in federal court on behalf of the Department of Justice and the Federal Communications Commission on two separate high profile cases involving wireless system design, implementation and operation.

Mr. Villecco has a BSEE from Drexel University, in Philadelphia. He is also a member of the Drexel ECE (Electrical and Computer Engineering) Department advisory board. In February 2001, Mr. Villecco received the "2001 Distinguished Alumnus Award" from the Drexel ECE Department for his continued contributions to the engineering profession. Since 1983, Mr. Villecco has been an active member of IEEE.

<u>Relevant Expert Witness Testimony Experience:</u>
Over the past fifteen years, Mr. Villecco had been previously qualified and provided expert witness testimony in the states of New Jersey, Pennsylvania, Delaware and Michigan. Mr. Villecco has also provided expert witness testimony in the following cases:

- United States Bankruptcy Court
- NextWave Personal Communications, Inc. vs. Federal Communications Commission **
- Pocket Communications, Inc. vs. Federal Communications Commission **

** In these cases, Mr. Villecco was retained by the FCC and the Department of Justice as a technical expert on their behalf, pertaining to matters of wireless network design, optimization and operation.

**David K. Stern**
**Vice President, V-COMM, L.L.C.**

David Stern, Vice President and co-founder of V-COMM, has over 27 years of hands-on operational and business experience in telecommunications engineering. He began his career with Motorola, where he developed an in-depth knowledge of the wireless engineering technologies CDMA, TDMA, and GSM, as well as AMPS and Nextel's iDEN.

While at V-COMM, Mr. Stern oversaw the design and implementation of several major Wireless markets in the Northeast United States, including Omnipoint - New York, Verizon Wireless, Unitel Cellular, Alabama Wireless, PCS One and Conestoga Wireless. He has testified at a number of Zoning and Planning Boards in Pennsylvania, New Jersey and Michigan.

Prior to joining V-COMM, Mr. Stern spent seven years with Comcast Cellular Communications, Inc., where he held several engineering management positions. As Director of Strategic Projects, he was responsible for all technical aspects of Comcast's wireless data business, including implementation of the CDPD Cellular Packet Data network. He also was responsible for bringing into commercial service the Cellular Data Gateway, a circuit switched data solution.

Also, Mr. Stern was the Director of Wireless System Engineering, charged with evaluating new digital technologies, including TDMA and CDMA, for possible adoption. He represented Comcast on several industry committees pertaining to CDMA digital cellular technology and served on the Technology Committee of a wireless company on behalf of Comcast. He helped to direct Comcast's participation in the A- and B-block PCS auctions and won high praise for his recommendations regarding the company's technology deployment in the PCS markets.

At the beginning of his tenure with Comcast, Mr. Stern was Director of Engineering at Comcast, managing a staff of 40 technical personnel. He had overall responsibility for a network that included 250 cell sites, three MTSOs, four Motorola EMX-2500 switches, IS-41 connections, SS-7 interconnection, and a fiber optic and microwave "disaster-resistant" interconnect network.

Mr. Stern began his career at Motorola as a Cellular Systems Engineer, where he developed his skills in RF engineering, frequency planning, and site acquisition activities. His promotion to Program Manager-Northeast for the rapidly growing New York, New Jersey, and Philadelphia markets gave him the responsibility for coordinating all activities and communications with Motorola's cellular infrastructure customers. He directed contract preparations, equipment orders and deliveries, project implementation schedules, and engineering support services.

Mr. Stern earned a BSEE from the University of Illinois, in Urbana, and is a member of IEEE.

**Sean Haynberg**
**Director of RF Technologies, V-COMM, L.L.C.**

Sean Haynberg, Director of RF Technologies at V-COMM, has over 21 years of experience in wireless engineering. Mr. Haynberg has extensive experience in wireless system design, implementation, testing and optimization for wireless broadband data and voice systems utilizing UMTS, HSPA, LTE, EVDO, CDMA, GSM, EDGE, ESMR and Analog wireless technologies. In his career, he has conducted numerous new technology deployments, compatibility & interference studies, and evaluations to assess, develop and integrate new technologies that meet industry and FCC guidelines. His career began with Bell Atlantic Mobile, where he developed an in-depth knowledge of wireless engineering.

While at V-COMM, Mr. Haynberg was responsible for the performance of RF engineering team supplying total RF services to a diverse client group. His projects included managing a team of RF Engineers to perform interference testing & analysis, FCC reporting and presentations, studying new wireless technology compatibility and integration with existing CMRS network technologies, conducting technology interference studies at CMRS base stations and customer provided equipment, design, deploy and optimize numerous CMRS wireless networks in various markets, wireless system design & expansion of international markets in Brazil and Bermuda, and development and procurement of hardware and software engineering tools. He has also developed tools and procedures to assist carriers in compliance to FCC rules & regulations for RF Safety, international TV band interference studies, and other FCC regulatory issues. In addition, Mr. Haynberg was instrumental in providing leadership, technical analysis, engineering expertise, and management of a team of RF Engineers to deliver expert engineering support and reporting on behalf of the FCC & Department of Justice, in the NextWave and Pocket Communications Bankruptcy proceedings.

Prior to joining V-COMM, Mr. Haynberg held various management and engineering positions at Bell Atlantic NYNEX Mobile (BANM). He was responsible for evaluating new technologies and providing support for the development, integration and implementation of first office applications (FOA), including CDMA, CDPD, and RF Fingerprinting Technology. Beyond this, Haynberg provided RF engineering guidelines and recommendations to the company's regional network operations, supported the evaluation and integration of new wireless equipment and technologies, including indoor wireless PBX/office systems, phased/narrow-array smart antenna systems, interference and inter-modulation analysis and measurements, and cell site co-location and acceptance procedures. He was responsible for the procurement, development and support of engineering tools for RF and system performance engineers to enhance the performance, design and optimization of the regional cellular networks. He began his career as an RF Engineer responsible for the system design and expansion of cellular markets in New Jersey, Philadelphia, PA; Pittsburgh, PA; Washington, DC; and Baltimore, MD markets.

Mr. Haynberg earned a Bachelor of Science degree in Electrical Engineering with high honors, and attended post-graduate work, at Rutgers University in Piscataway, New Jersey. In addition, Mr. Haynberg has qualified and provided expert witness testimony in the subject matter of RF engineering and the operation of wireless network systems for many municipalities in the State of New Jersey.

**David Hunt**
**Senior Staff RF Engineer, V-COMM, L.L.C.**

Mr. Hunt has over 27 years of experience in RF engineering including extensive experience in wireless planning, RF design, optimization, and performance of wireless systems utilizing OFDM, CDMA, EVDO, GSM/GPRS/EDGE, UMTS/HSPA, LTE, SMR/IDEN and other wireless technologies. In his career, he was responsible for the specification, design, proof-of-performance tests, implementation, and optimization of numerous wireless communications systems, detection and measurement systems including advanced military systems. His career began in the specification, design, and implementation of underwater acoustic warfare systems and continued with commercial wireless communications systems while at V-COMM.

While at V-COMM, Mr. Hunt has been responsible for the performance of a RF engineering team supplying a variety of RF services to a diverse client group. Projects include: system performance monitoring, frequency planning, adjacent market coordination, inter-modulation analysis, RF propagation prediction, system technology evaluation. Mr. Hunt designed, tested, optimized, and maintained new and existing cellular, PCS, MMDS, SMR, 700 MHz and other wireless voice and/or data systems throughout the United States and the Caribbean. In addition, Mr. Hunt has been involved in special technology evaluations and the development and procurement of hardware and software engineering tools to enhance both V-COMM and its client's capabilities. Mr. Hunt has lead the development of tools and procedures to assist clients and carriers in meeting compliance with FCC Rules & Regulations for RF Safety, emission standards and other FCC regulatory issues including FCC, FAA and AM tower studies and filings. David's activities included the development and submission of comprehensive engineering studies for consideration in numerous FCC proceedings.

While at the Naval Air Warfare Center (NAWC), Mr. Hunt designed and wrote computer programs to generate and display antenna beam pattern for various conditions of a linear array of hydrophones for display of receiver gain calculations. He documented this work in Technical Memorandum 5032 TM-887-IBP-08. Mr. Hunt was involved in all aspects of the SSQ-101 Air Deployable Active Receiver (ADAR) sonobuoy development including: signal processing software, hardware design and development, test planning, setup and testing. Mr. Hunt designed, developed and implemented an All-Threat In-Buoy Signal Processing (IBSP) Program used to detect, classify and localize enemy targets on the SUN workstation using standard signal to noise ratio measurements and advanced detection methods. This involved analyzing signal to noise ratio performance requirements and the design/implementation of specific portions of the preprocessor including modulation, filter decimation, windowing with redundancy, frequency analysis, magnitude/phase detection and a short term integration process.

While at NAWC, he received seven Performance Awards, a Quality Step Increase, three Letters of Appreciation, and one Special Act Award.

Mr. Hunt has a Bachelor of Science Degree in Electrical Engineering from Temple University emphasizing Signal Processing, Digital Signal Processing and Communications. In addition, Mr. Hunt has earned a Masters of Science Degree in Electrical Engineering from Drexel University in Philadelphia.